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Trust and Communications in HSCB Simulations

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ABSTRACT

Trust plays a critical role in communications, strength of relationships, and information processing at the individual and group level. Cognitive social simulations show promise in providing an experimental platform for the examination of social phenomena such as trust formation. This work is a novel attempt at trust representation in a cognitive social simulation using reinforcement learning algorithms. Initial algorithm development has been completed in a standalone social network simulation centered around a public commodity game. Following this testing the algorithm has been imported into the Cultural Geography model for large scale test and evaluation.

CENTRAL RESEARCH QUESTION

What is the best method for modeling trust in HSCB simulations?

Breaking the central research question down leads to the following …

- What is trust? In other words, how can define trust in a concise way so as to develop a working computer model of it?
- How does trust impact communications within a social network? More to the point, how can we tune our trust algorithm to produce the effects of trust as actually observed in real social networks?
- To facilitate an implementation of trust within a social simulation, what will be the best format for communications between agents?
- When a model of trust has been implemented, what data requirements will there be to populate the model?

What is trust?

Reputation

Familiarity

Opportunity

What is trust?

Respect

Responsibility

Confidence

What is trust?

- Easy to speak about casually - very difficult to precisely define - even more difficult to model.
- Our trust model will be mostly involved with communications, therefore we have adopted a definition of trust that is most useful to that end.
- DEFINITION: Trust is an agent's perception of another agent's adherence to an unspoken social contract as well as how faithfully the other agent will conform to preconceived actions based on their past actions or perceived characteristics.
  - This social contract encompasses relationships between that agent and other individuals as well as between that agent and the larger group.

The key elements of trust that we have focused on with this implementation are reputation, prejudice and ambition.

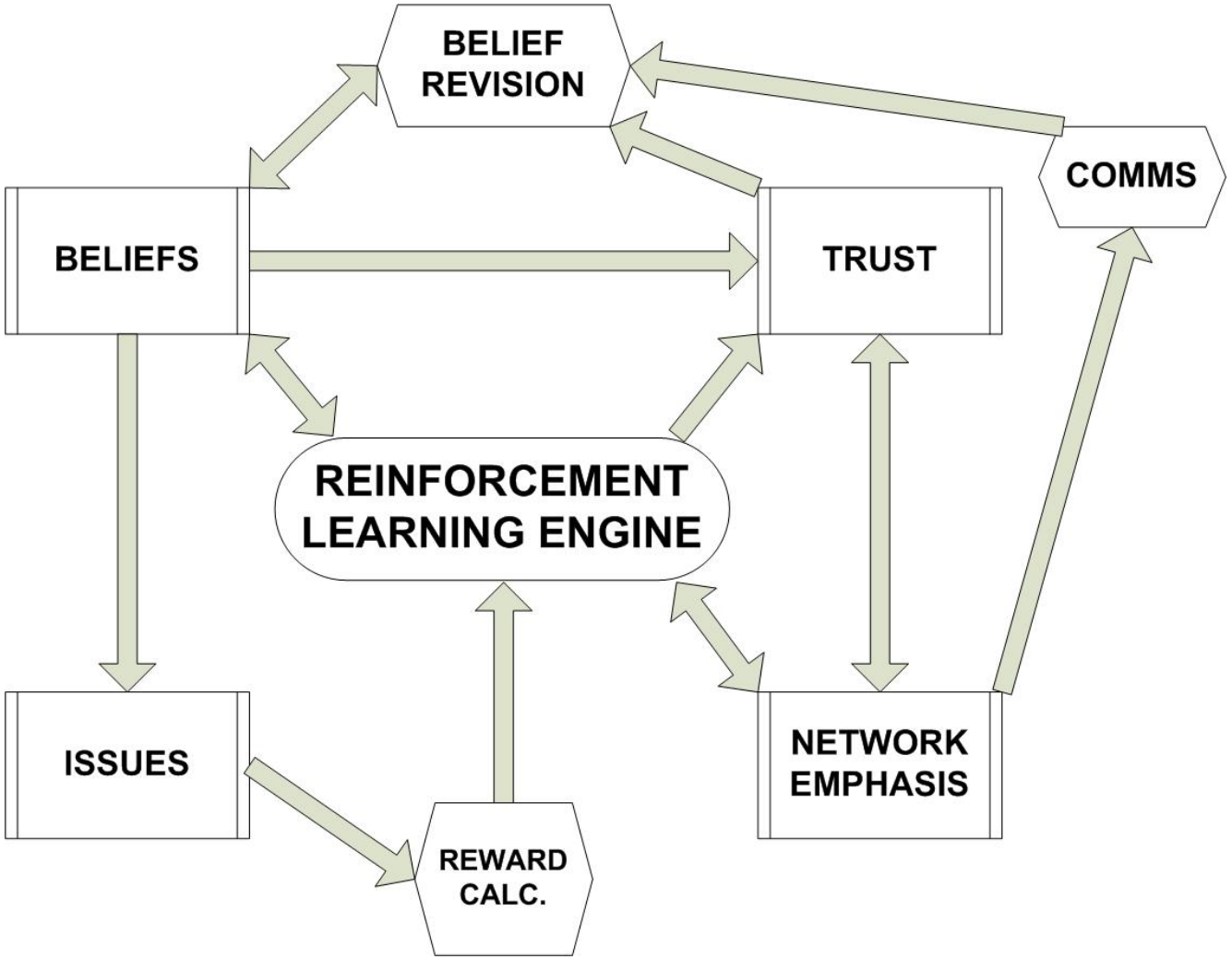
- Reputation: A measure of an agents past actions as a predictor of future actions.
- Prejudice: A baseline trust based on social similarity (homophily).
- Ambition: Loosely defined to encompass the agents desire for reward, and willingness to risk interacting with potentially untrustworthy agents.

A subtle modification to our definition of trust: Our model of trust is based on action, not solely on internal trust alone.

Applying Reinforcement Learning to the Problem

- Reinforcement Learning (RL) is a form of machine learning that allows an agent to make informed decision based on a given state and a selection of possible actions.
- As the agents make a series of actions they come across rewards which reinforce the state-action pairs in their history. The form of reinforcement utilized in our algorithm is Q-Learning in which reinforcements are determined as follows:
    - $Q(s,a) \leftarrow Q(s,a) + \alpha(r + \gamma max_{a'}(Q(s',a')) - Q(s,a))$
- *Agents use the Q-value (Q(s,a) above) to determine their best choice of possible actions. There are many methods for choosing amongst actions, each with a given Q-value. The particular method employed by our algorithm is a softmax or Boltzmann selection technique where the probability mass function of a given action is as follows:*
    - $P'(a|s) = e^{Q(s,a)/t}$

Reinforcement Learning Drives the Trust Algorithm



Algorithm Overview

Incoming Comm:

- State is defined as the sender and the subject.
- Agent will choose to increase, decrease or keep steady their trust level in the sender.
- If the sender's new trust level exceeds a minimum value the information is received and processed.
- Beliefs are changed based on the new information.
- Beliefs drive the agents other actions and have a direct effect on the happiness of the agent.
- Happiness is calculated and used as the reward signal for the trust algorithm.

Outgoing Comm:

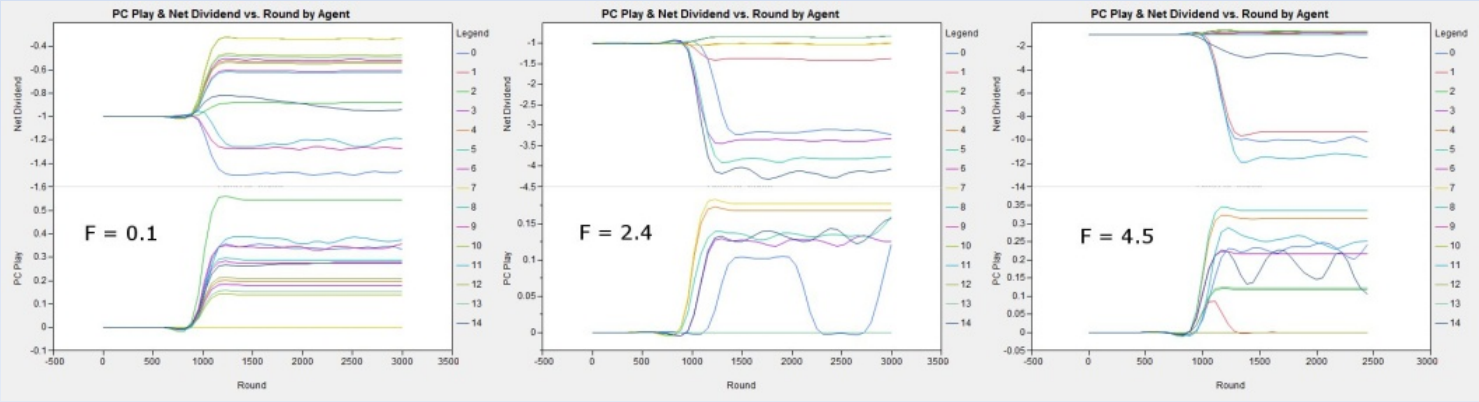
- State is defined as the possible receivers and the subject. (one pass through the algorithm for each)
- Agent will choose to increase, decrease or keep steady their trust level in the possible receivers.
- If the receiver's new trust level exceeds a minimum value the information is sent.
- Receiver's beliefs are changed based on the new information.
- Beliefs drive the agents other actions and have a direct effect on the happiness of the receiver and his neighbors (including the sender).
- Happiness is calculated and used as the reward signal for the trust algorithm.

Putting Trust to the Test

- There have been many classic games of trust that test their human subjects' responses when faced with unique trust scenarios.
- Our test is a variant of the Public Commodity (PC) game.
- The public commodity game has been studied in depth for many years. In real experiments, the semi-stable long time average contribution will be relatively low, but nonzero.

Overview of Testing Results

- In standalone testing we find that the average contributions to the public pot are predictably low, but nonzero.
- We also find that when we add a penalty to the reward signal that penalizes for an agents to change their initial beliefs, we see shifting behavior as shown below:



Application to Cultural Geography

- **The Cultural Geography model is a social simulation that is being developed in Simkit in which a small society of autonomous agents interact with each other, external agents and commodity providers.**
- **The agents make decisions on particular courses of actions, on of which is the choice to communicate with the other agents. The trust algorithm is inserted into this decision as a filter in order to aid the agent in choosing who to communicate with as well as which agents to trust communications from.**
- **As agents either successfully or unsuccessfully acquire commodities (food, water, gas, etc) or observe events (IED, etc), they will refine their belief structure. The agents beliefs are represented in Bayesian Networks that give the agents Issue Stances such as their opinion of the local insurgency or of the coalition forces in their town.**
- **The effects of the trust filter can be seen as we watch the evolution of the issue stances both with and without the trust filter in place.**

CONCLUSION

- Based on these results it is easy to see that reinforcement learning can go a long way in simulating trust behavior in social simulations, but there is a lot of work still to be done
- Future work will seek to incorporate a more cognitive approach to work in concert with the central reinforcement learning algorithm.